Transtracheal Resuscitation

An Experimental Study in Dogs

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■ *Previous experimental studies of the use of a large bore needle for transtracheal resuscitation have shown that arterial oxygen saturation can be maintained at satisfactory levels. Accumulation of carbon dioxide and subsequent fall of arterial pH has been the limiting factor in this mode of resuscitation.*

The present study was undertaken to demonstrate experimentally in dogs the use of an Intracath® 14 gauge needle for transtracheal resuscitation. Oxygen was administered transtracheally to five anesthetized apneic dogs for 30 minutes through this needle by the Bird respirator. Carbon dioxide could not be adequately exchanged by this method, but satisfactory levels of arterial oxygenation were maintained and all the experimental animals survived.

IDEALLY ALL PHYSICIANS should be trained to perform tracheotomy but it is probable that not many have had much experience with this procedure. In acute respiratory obstruction, such as may occur, for example, in epiglotitis or laryngotracheobronchitis, time may be of the essence. A mode of resuscitation should be available which can be easily utilized. Transtracheal resuscitation might serve this function.

Concepts of transtracheal resuscitation date from the 17th Century when Robert Hooke,[4] before the Royal Society of London, pumped air into the lungs of dogs and maintained life for well over an hour without respiratory movement. In 1944, Draper and coworkers[1] reported on experiments with diffusion respiration in which pure oxygen at one atmosphere was allowed to diffuse into the lungs of dogs while the animals were maintained in complete respiratory arrest for periods of 45 minutes. Jacoby and coworkers[6] in 1951 reported on transtracheal artificial respiration with oxygen insufflation through a 13 gauge transtracheal needle. They were able to maintain life in dogs for 30 minutes with an expected recovery rate of 100 per cent. Reed and coworkers[7] repeated this study in 1954 and noted a fall in arterial pH and a rise in arterial oxygen content and carbon dioxide tension. After 30 minutes of transtracheal respirations through a 13 gauge needle, they introduced a larger tapered needle transtracheally and carried out ventilation for an additional 30 minutes. All blood values and vital

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signs returned to normal. Postmortem studies revealed no evidence of hemorrhage or injury to tissues of the neck, trachea or lungs.

In 1956, Jacoby and coworkers[5] induced apnea immediately before operation in patients with malignant disease of the upper respiratory tract. An 18 gauge needle was inserted transtracheally and oxygen was administered at four liters per minute. Reversal in the progress of anoxia was noted within 30 seconds and oxygen saturation returned to normal within two minutes. These patients were artificially ventilated for periods of from five to 52 minutes.

In transtracheal resuscitation, a large bore needle is placed through the soft tissues of the neck into the trachea either through the cricothyroid membrane, the most constant landmark, or between the upper tracheal rings. Oxygen is administered through the needle at five to ten liters per minute. Life can be maintained without untoward effects for 30 minutes provided definite treatment is instituted within this period. The limiting factor is the build-up of carbon dioxide with resultant respiratory acidosis.

A majority of investigators[3,5,6,7] have recommended either a 13 or 14 gauge needle. Few hospitals have needles larger than 18 gauge readily available. In recent years, disposable non-surgical type cutdown sets such as the Bardic® Deseret Intracath® Unit* have been developed. The large size is supplied with a 14 gauge needle. These sets are being used in many hospitals and are usually available on each floor. Feder,[2] noting its accessibility, suggested the use of this needle for transtracheal resuscitation.

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The present study was undertaken to demonstrate the use of the 14 gauge Intracath® needle in transtracheal resuscitation.

Method

Anesthesia was induced in five adult dogs ranging in weight from 9.5 to 28.6 Kg by intravenous administration of pentobarbital sodium. The femoral artery was cannulated with a polyethylene catheter, passed into the aorta and attached by means of three-way stopcock to a Statham strain gauge. Pressures and pulse rates were recorded on the direct writing recorder.

Specimens of blood were drawn from the femoral catheter at 10-minute intervals. Determinations of the arterial pH and carbon dioxide tension were performed with an Astrup ultramicro apparatus. Arterial oxygen saturations were determined with a Beckman Model DU spectrophotometer.

The animals were intubated with cuffed endotracheal tubes and maintained in the apneic state by the administration of pentobarbital and succinylcholine. Respirations were maintained by endotracheal administration of 100 per cent oxygen at pressures of plus 10 and minus 4 cm of water at 16 to 18 cycles per minute. After 30 minutes of assisted endotracheal respirations, the tubes were clamped and an Intracath® 14 gauge needle was inserted into the trachea through the thyrocricoid membrane or between the upper tracheal rings. By reversal of the plastic hub (Figure 2)

TABLE 1.—*Data on Five Adult Dogs in Which Ventilation Was Maintained by Transtracheal Insufflation*

Dog	Weight Kilogram	Determination	Pulse	Blood Pressure mm of Mercury	pH	P CO_2 mm of Mercury	O_2 Saturation Per Cent
1	28.6	Control*	150	210/130	7.38	21.0	92.0
		Transtracheal†	100	170/115	6.94	115.0	88.0
		Revival‡	150	160/125	7.29	31.0	92.0
2	17.7	Control	180	175/100	7.43	28.0	98.6
		Transtracheal	105	200/120	6.83	137.0	99.2
		Revival	165	165/80	7.25	36.5	99.1
3	22.2	Control	155	165/130	7.45	28.5	99.5
		Transtracheal	130	180/120	7.05	100.4	85.0
		Revival	150	170/145	7.44	32.0	100.0
4	21.2	Control	120	130/90	7.56	22.0	94.5
		Transtracheal	120	150/100	7.15	71.0	95.0
		Revival	160	130/96	7.38	35.5	100.0
5	9.5	Control	160	160/120	7.48	28.5	99.0
		Transtracheal	150	200/120	6.94	122.0	98.8

*Control—average of samples taken at 10 minute intervals during initial 30 minutes of endotracheal respiration.

†Transtracheal—results after 30 minutes of transtracheal oxygen insufflation.

‡Revival—results following ten minutes of assisted endotracheal respirations.

N.B.: Dog No. 5 was revived immediately following 30 minutes of transtracheal insufflation.

normally attached to the needle (Figure 1), a No. 6 Bird tracheal adapter (Figures 1 and 2) was attached to the hub, allowing for connection to the Bird respirator by interposition of an accordion connector (Figures 1 and 2). Transtracheal respirations were maintained for 30 minutes using 100 per cent oxygen at pressures of plus 30 and using 100 per cent oxygen at pressures of plus 30 and minus 5 cm of water, at 20 cycles per minute. The needles were then removed and the dogs were ventilated endotracheally for the final 10 minutes.

Results

Results are listed for each of the dogs in Table 1. Changes in the arterial pH and carbon dioxide tension began immediately after transtracheal respirations were begun. The pH fell from an average control level of 7.45 to 6.98 in 30 minutes. After resumption of endotracheal respirations for the final 10 minutes, the pH was 7.34.

Carbon dioxide tension rose from an average control level of 27.6 mm of mercury to 111 mm of mercury after 30 minutes of transtracheal insufflation. With the resumption of endotracheal respirations in the final 10 minutes, the level returned to an average of 33.7 mm of mercury.

No significant changes were noted in the oxygen saturation during transtracheal oxygenation nor were consistent changes seen in the arterial pressures. A slight decrease in pulse rate was recorded but returned to control levels during the final 10 minutes. All the experimental animals were easily revived.

Discussion

The data confirms previous work[3,5,6,7] demonstrating that dogs anesthetized to a state of complete respiratory arrest can be adequately maintained for 30 minutes by intermittent insufflation of oxygen through a transtracheal needle and then revived without ill effect. A large size Intracath® needle was successfully utilized for transtracheal resuscitation.

Slight motion of the diaphragm was noted during transtracheal insufflation with the Bird respirator. This motion was insufficient to produce adequate respiratory exchange. Excess carbon dioxide could not be removed in adequate amounts during the negative phase of the cycle. The carbon dioxide build-up cannot be reversed because of the small bore of the needle in relation to tracheal diameter.

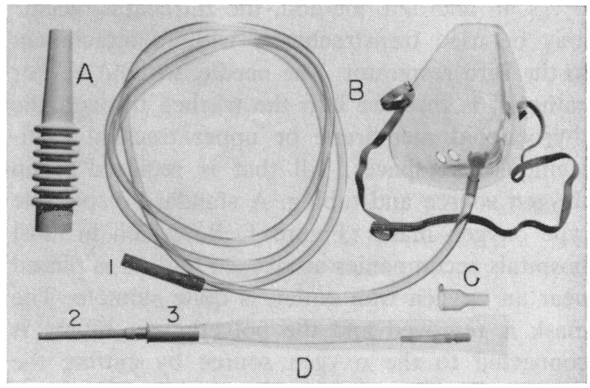

Figure 1.—Apparatus: A, Bird accordion connector, standard on machine; B, Standard disposable oxygen mask; 1, Rubber connector to oxygen source; C, No. 6 tracheal adapter for accordion connector; D. Bardic, Deseret Intracath® Unit, large; 2, 14 gauge needle in sheath; 3, Plastic hub.

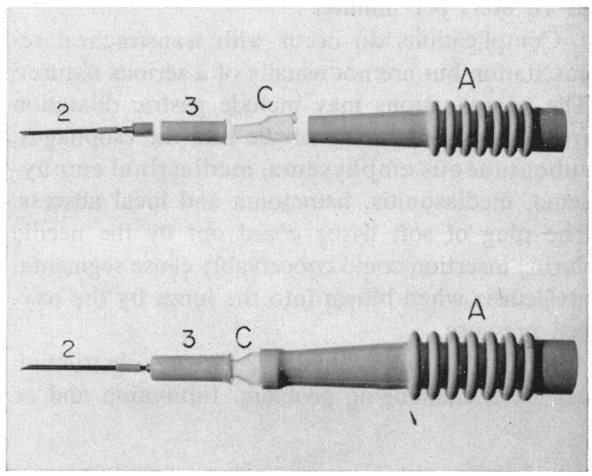

Figure 2.—*Above*, apparatus as used in experiment, unassembled; 2, No. 14 needle; 3, Hub reversed; C, No. 6 tracheal adapter for Bird; A, Bird accordion connector. *Below*, apparatus assembled as used in experiment.

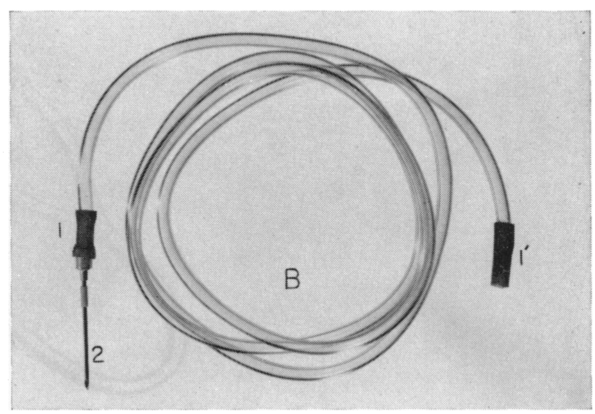

Figure 3.—Apparatus suggested in cases of emergency when Bird unavailable; 2, Intracath® 14 gauge needle; 1 and 1′, rubber connector (as shown in Figure 1) cut into two equal parts, each connected to ends of tubing, after removal of mask. 1 connects to oxygen source, 1′ to No. 14 needle.

As an alternate method, the Intracath® needle may be used transtracheally without attachment to the Bird respirator. The needle, without hub or catheter, is inserted into the trachea through the thyrocricoid membrane or upper tracheal cartilaginous interspaces. All that is required is an oxygen source and tubing. A standard disposable type oxygen mask (Figure 1, B) which in most hospitals accompanies an oxygen tank or is placed near an oxygen wall outlet, is quite suitable. The mask is removed and the polyethylene tubing is connected to the oxygen source by cutting the rubber connector (Figure 1, 1) into two equal parts and placing one-half at each end of the tubing (Figure 3, 1 and 1′). One end is connected to the 14 gauge Intracath® needle, the other to the oxygen source. Oxygen is then administered at 8 to 10 liters per minute.

Complications do occur with transtracheal resuscitation but are not usually of a serious nature.[7] The complications may include gastric dilatation from placement of the needle into the esophagus, subcutaneous emphysema, mediastinal emphysema, mediastinitis, hematoma and local abscess. The plug of soft tissue cored out by the needle during insertion could conceivably cause segmental atelectasis when blown into the lungs by the oxygen pressure.

In dealing with children, airway obstruction can be a challenging problem. Intubation and or tracheotomy may be quite difficult. The airway can be maintained in the pediatric emergency by the transtracheal technique.

This mode of resuscitation is suggested for emergency use only, and can only be employed in a hospital where oxygen is available. It is not meant as a substitute for orderly tracheotomy, but as a useful adjunct in resuscitation when tracheotomy cannot be readily performed. This technique should be used for as short a period as possible.

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